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A N T H R A C I T E C U L M A N D S I L T .

By James D. Sisler.

Since active mining of anthracite started 100 years ago, enormous quantities of mineral waste have accumulated within the region. There are at least three objections to the accumulation of this material: it contains a large quantity of valuable fuel, much of which cannot be recovered at a profit; much of it washes into streams tributary to the anthracite region, filling and polluting them and causing damage to property and industries along their banks; the accumulations occupy much land valuable for other purposes and are unsightly. For many years there has been discussion as to the exact quantity and character of the coal in the culm piles and silt banks, as to better methods of recovery of the fine sizes of anthracite at the collieries, as to possible economic uses to which these fine sizes could be put, as to how further pollution and silting of the streams could be prevented.

Several State commissions and boards have studied the problems but have added little to their solution. In the meantime great progress has been made by individual companies in increased recovery and in utilization of the fine coal, and there has been a great advance in the construction of equipment for fine coal recovery, coal cleaning, and coal utilization, including the use of briquettes and powdered coal.

July 1, 1925 the U. S. Bureau of Mines, the Topographic and Geologic Survey of Pennsylvania and the Water Power and Resources Board of Pennsylvania instituted an exhaustive study of the production and utilization of fine-sized anthracite. Its purpose was two-fold; the first phase of the study was to answer



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the questions of briquetting companies, Public Service corporations, fuel burning equipment companies, foundries, machine shops, and river coal operators. Where are the silt and culm deposits to be found? How much of this material is available? What is its quality? How can it be used? The second phase of the investigation concerned stream pollution and channel silting and its damage to industries and property in and outside of the anthracite-producing territory. It was the purpose of this part of the study to determine accurately just where stream pollution originates, what is being done to stop it and what progress had been made since the subject was studied in 1915.

The results of this investigation have been compiled and a manuscript is now ready for printing. The somewhat unusual demand for the information contained in this bulletin has made it desirable to issue in this form the conclusions and salient facts which will appear later in printed form as Bulletin H 12 of the Topographic and Geologic Survey of Pennsylvania.

Anthracite mining differs from other mining in that the sharp pitch and character of the beds makes it necessary to bring waste material to the surface along with the coal. The public has been taught to use anthracite in its prepared form and it must be prepared properly. The waste material which results from mining, sizing and preparation must be discarded. Economic conditions and market competition with other coals have made it necessary to discard this waste material in the most economic manner; it must be piled near its source with the least possible handling, leading to the accumulation of enormous banks of silt, culm and rock on breaker properties. Because of the steep hillsides and narrow valleys common in the anthracite region, it is almost impossible to store the material so that some of it will not go into the streams.

As steeper and less pure beds are mined the quantity of waste material will increase rather than decrease. The problem is one of the future rather than of the past. The ultimate problem is not of confining the waste material to the place where it is stored but of finding some use or some means for its disposal. The casual observer is likely to come to false conclusions and offer false remedies for the situation. Any solution of this problem must be based upon detailed scientific data as presented in Bulletin H 12.

Conclusions.

The sampling work upon which the estimates of silt losses are based represents an aggregate yearly tonnage of 10,664,000 tons, or approximately 17 per cent of the total annual production of anthracite well distributed over the fields. This percentage is enough to yield reliable data as to the quantity of silt and culm accumulations throughout the anthracite field and as to the total annual production of silt.

Silt and culm deposits range in size from a few thousand tons to 10 million tons. The coal in banks in the anthracite region ranges widely both as to purity and percentage of commercial sizes. There are general regional differences in the character of the coal beds and in mining conditions that affect the character of the silt which is produced in the various mining districts.

The "oversize" (coal which will not pass through a 3/32" screen) in new banks and current silt ranges in the Northern Field from 1 to 16 per cent. The normal is 4 to 6 per cent and new collieries lose only 1 to 2 per cent of commercial-size coal. A larger percentage of oversize is apparent in the silt in the Southern Field than elsewhere, except that the Panther Valley mines have practically no loss. Where auxiliary shakers are used to re-screen the silt before it goes to the bank, the loss of No. 2 Buckwheat is generally under 2 per cent.

The percentage of slime, or material which passes through a 200-mesh screen, is also subject to regional variation. It increases from north to south and from east to west with local variations. It is due primarily to the physical character of the coal and the inclination of the beds. The -200 mesh material in samples of silt from freshly mined coal ranges from 13 to 15 per cent at most of the Wyoming Valley collieries, to over 30 per cent at collieries in the Southern Field. The percentage of fines in silt banks depends primarily upon the method of handling silt from the washery to the bank and the effectiveness of settling. Therefore, the proportion of silt through 200 mesh varies in local accumulations from 2 per cent to the total quantity in the original silt which is produced from mine run coal, or even more if much bank coal has been handled in the preparation plant. The purity of the fine coal discharged at various collieries varies, like the size, with local mining conditions and preparation practices. Certain regional averages are constant excepting cases where unfavorable conditions prevail. The raw silt discharge from plants which treat fresh mined coal in the Wyoming Valley is 20 to 25 per cent ash. In the Eastern Middle Field it normally is 25 to 30 per cent ash; and in the Western Middle and Southern fields from 30 to 40 per cent, decreasing toward the west. Lykens Valley silt is particularly low in ash. Float and sink tests show that throughout the anthracite fields it is possible to reduce the ash content of the silt to 10 or 12 per cent by rejection of 15 to 16 per cent of the raw material as refuse. The high ash content of the raw untreated silt in certain fields is accounted for by the excessive quantity of dirt that is mixed with it in mining and not by the inherent high ash content of the coal.

The calorific value of the coal in silt banks that have stood for some time is a little lower than that of the fresh mined coal of the same ash content. This deterioration varies with the age of the bank and is over 4 per cent in the most extreme case of weathering. The coal that has been in silt banks for five to ten years, has 100 to 200 B.t.u's lower calorific value than fresh mined

coal of the same ash content from the same collieries. In banks that have been exposed for 40 years this difference is as much as 500 B.t.u's per pound.

In normal fresh silt the ash content increases progressively with decrease in size of particles so that the dust through 200 mesh, which is of suitable size for burning as powdered coal without grinding, is practically worthless because of high ash content. At most collieries where samples were taken this product contained approximately 50 per cent ash.

Estimated Yearly Silt Production. Estimates based on the ratio of culm and silt production to production of prepared coal at all the mines that were sampled in the four major divisions of the anthracite field fixes the total annual production of silt at approximately 8,900,000 tons. Plants handling fresh mined coal in the Wyoming Valley produce approximately 13 per cent as much silt as prepared coal. In the Eastern Middle Field the ratio of silt to prepared coal is about 16.5 per cent, in the Western Middle Field 14 per cent, and in the Southern Field 17.5 per cent.

Losses of Fine Coal in Waste Water. The quantity of coal lost in waste water discharged in the streams depends entirely upon the method of handling at the individual collieries and has no relation to geographic position or mining conditions. Furthermore, extreme variation in conditions is often found at adjacent collieries. At the collieries studied in the Northern Field the loss of fine coal in waste water discharge from preparation plants is 1.6 per cent of the quantity of coal shipped. In the Eastern Middle Field this ratio is 1.3 per cent, in the Western Middle Field 2.7 per cent, and in the Southern Field 1.8 per cent. The total loss of fine coal discharged in the streams is approximately 1,150,000 tons annually. In addition to this quantity much coal is washed into the streams from old banks. Rainy seasons and floods are the cause of this secondary pollution. Screen analyses show that practically all of this material is finer than the smallest of the present commercial sizes of coal and is comparatively high in ash content. The small quantity of domestic sized coal which is being added to the stream deposits is washing out of culm, silt and rock banks and not from current breaker refuse. Silt and culm banks contain 20 to 80 per cent combustible matter. Rock banks of wet breakers contain less than 3 per cent combustible material.

Quantity of Silt and Culm by Fields. The following table gives the quantity of silt, culm and mixed materials now stored in banks in the Anthracite Fields. This material ranges from 20 to 80 per cent combustible matter. The figures are long tons.

Quantity of culm and silt, in long tons

Field	Culm	Silt	Mixed	Total
Southern	37,745,000	36,815,000	10,000,000	84,560,000
Western Middle	43,785,000	40,735,000	17,175,000	101,695,000
Eastern Middle	2,450,000	6,200,000	1,385,000	10,015,000
Northern	8,125,000	8,055,000	1,795,000	17,935,000
Total for all fields	92,085,000	91,785,000	30,355,000	214,225,000

It is almost impossible to estimate the quantity of material in the streams in the anthracite region, but estimates of some of the river deposits lead to a reasonable guess that in the streams in the anthracite region and leading from it there are at least 900 million tons of material which contain enough coal to make future recovery profitable when market conditions will permit.

Production of Fine-sized Anthracite. Methods of mining have more influence upon the production of fine sized anthracite than any other mechanical cause. Improvements have not kept pace with improvements in the preparation and handling of coal after it is mined. The percentage of fine sized coal which is produced could be reduced by installing more modern methods of mining. Anthracite companies are gradually paying more attention to this important factor. The old room and pillar system which was used for years without modification is now being adapted to local mining conditions with good results. The installation of mechanical mining machinery is also reducing the percentage of fine sizes.

Preparation of Anthracite. The secondary production of fine sized anthracite originates after the coal has left the mine. Very little if any separation of coal from impurities is now done in the mine. The entire product, coal, slate, bone and clay is hoisted to the top of the breaker. Formerly, practically all the coal was prepared by the dry method which resulted in production of very little silt. Today practically every breaker in the anthracite region uses the wet method of separation which produces the black breaker water which runs out upon the silt banks or goes directly into the streams. It is not the purpose of this mimeographed bulletin to discuss in detail the method of preparation of anthracite. The coal is screened, jigged, and cleaned by various methods. New methods of cleaning anthracite are reducing the quantity of fine sizes produced in the breaker. Various thickeners, concentrators, and settling tanks for recovering and settling the fine sized anthracite are now a part of the usual breaker equipment.

Uses of Anthracite Silt and Culm. Before the problem of the disposal of this burdensome material can be solved it is necessary to find a use for it. Transportation cost is the greatest single problem. Material which has a market value of less than 50 cents a ton at its source must be sold for \$3.00 or \$4.00 a ton at a point some distance away. Although there are many uses for this material, all of them combined could not utilize the entire annual output, and certainly not the enormous banks which have already accumulated. The only solution of the problem seems to be to use the material at its source. Burning it on mechanical stokers and in pulverized form for power production seems to be the most logical manner to utilize it. The lack of sufficient supply of water is a serious problem in power generation in the anthracite region.

Two power plants in the anthracite region are now using silt in powdered form. Numerous others are using silt directly upon mechanical stokers but the efficiency is not high. When anthracite is used in powdered form it must be dried and pulverized and fed into specially constructed boilers by various mechanical devices. This method is now being used and the cost of preparing the fuel for burning ranges from 50 to 90 cents a ton. Where the silt is near or on the site of a boiler plant it can be prepared for as low as 30 cents per ton. One plant outside the anthracite region is using a mixture of powdered anthracite and bituminous coal with much success. In the vicinity of Harrisburg, river coal, which resembles very closely the material stored in silt banks, is being used with good results for power generation purposes by several companies.

Some of the small producer gas plants in eastern Pennsylvania are using fine sized anthracite. Molds for certain types of metal castings are faced with a thin film of anthracite dust. Probably the greatest potential market for anthracite silt is in the manufacture of briquettes and other types of prepared fuel. The briquette industry is now on a substantial basis and is growing from year to year.

The value of fuel briquettes manufactured in 1925 was \$7,128,000. Of this amount \$1,842,000 was produced in the Eastern States. Practically all of these briquettes were made of anthracite, 387,000 tons of anthracite culm and silt being used for this purpose in 1925. Four plants are using anthracite waste for the manufacture of briquettes on a commercial basis. The public has formed a prejudice against manufactured fuels because most of them have been unsatisfactory or at least were not as good as fuel in its natural form. These difficulties were principally mechanical and research is gradually eliminating objectionable features and is enabling manufacturers of briquettes to put their product on the market at a price which will compete with the natural fuel.

Silt, Culm and Breaker Discharge Conditions at Individual Collieries and in the Streams. During the summer of 1925 all the collieries producing anthracite silt were visited to investigate what disposal was being made of the breaker water, to estimate the contents of the culm and silt banks, and to observe the methods of recovery of fine sizes in the breaker water. Each stream was carefully studied and observations were made of the silt accumulations. These detailed studies were necessary to lay a basis for the larger conclusions.

The Southern Anthracite Field is drained by Nesquehoning Creek, Panther Creek, Little Schuylkill River, the West Branch of the Schuylkill, and by Swatara Creek and Wiconisco Creek. The water of Nesquehoning Creek is black and there is a large accumulation of silt in the creek valley at Nesquehoning. The creek flows through a sparsely populated territory and no damage is done along its course. Panther Creek flows through a narrow valley and silt accumulations are present practically everywhere in its channel. Little or no damage is being done by the silt and breaker water. The water of the Little Schuylkill from Tamaqua south is black. More silt is added south of Tamaqua from the old culm banks along the hillsides and the Little Schuylkill carries much solid material. Schuylkill River carries the mine drainage from a large area and the river deposits annually large tonnages of silt. Its flood plain is built up at many places with silt accumulations. The West Branch of Schuylkill River is also heavily laden with silt. It drains an area in which are located collieries having an enormous daily output. Practically all of these collieries have settling tanks but even under the best conditions some silt goes into the streams. Swatara Creek carries the drainage from four active collieries. Much silt is deposited at points where the stream is sluggish. The wash from old culm and silt banks adds appreciably to the silt content of the stream. Little difficulty is experienced in keeping the stream from doing property damage. Wiconisco Creek drains the Lykens district. The creek keeps its channel clean and although the water is black there is very little evidence of silt deposition the entire length of its course.

The Western Middle Coal Field is drained by three principal streams, Mahanoy Creek, Shamokin Creek, and Zerby Run. The latter stream contains the drainage from two active collieries. The water is black and carries much solids but it does very little damage to the farms through which it flows. The waters of Mahanoy Creek are the heaviest laden with silt of any waters in the anthracite field. The creek flows through a narrow valley from Mahanoy City southwestward and eats into culm and silt accumulations which encroach upon its banks. Shamokin Creek, and Mahanoy Creek are very black and contain large quantities of solids. These two creeks have caused much local damage and inconvenience in time of high water. This condition is obviously a necessary evil because the towns themselves depend upon the coal industry for their existence. Shamokin Creek has caused serious difficulty in the vicinity of Mount Carmel when its channel became clogged with the silt. This condition is now wo-

controlled. The discharge of silt in Shamokin Creek is much less than it has been in former years. The creek will gradually clean its channel and within a few years practically all the deposits along its banks will disappear.

The silt-laden streams from the Eastern Middle Coal Field, namely Pond Creek, Sandy Run, Black Creek, Hazle Creek, Beaver Creek, and Catawissa Creek contribute silt to the main streams but cause no local damage. Practically all of them flow through sparsely populated territory.

The Northern Anthracite Field is drained by Lackawanna and Susquehanna Rivers and their tributaries. The water is heavily laden with solids and much deposition takes place. Many collieries are discharging breaker water directly into the stream without first settling it. The flow of these two rivers is large enough to keep the channel clean. In the vicinity of Scranton the channel has been narrowed by encroachments until the silt has backed up into the sewers. Local conditions along the tributaries of these two rivers have caused some damage.

River and Creek Coal. The three rivers draining the anthracite fields, the Susquehanna, Schuylkill and Lehigh, have been carrying away thousands of tons of combustible material annually for over 100 years. This material has its source at the old accumulations of culm, silt, and rock, at the new deposits of silt, and from current breaker water. The deposits of coal in these rivers have been a fruitful source for coal dredging operations. Most of the river coal is recovered from the Susquehanna and its tributaries, Wiconisco, Mahanoy, Shamokin and Swatara Creeks. Schuylkill River is second in importance as a river-coal producer. All of the dredging operations in this river are between Pottsville and Reading. Lehigh River drains only a small part of the anthracite field and very little coal is being produced from the accumulations along its banks.

Approximately 10 million tons of coal have been recovered from the rivers and creeks draining from the anthracite field. This coal sold from 50 cents to \$3.50 a ton. In 1925 there were 46 river coal operations; 791,000 tons of coal was recovered.

Opinion differs among river coal operators as to the life of the industry. This industry does not depend entirely upon supply; but rather upon economic conditions. In all probability the river coal operations, particularly on the Susquehanna, will continue for many years. In the past large quantities of domestic sizes have been recovered from the river. In the last few years 50 to 65 per cent of the coal goes through a 3/32 inch round mesh screen. A typical average size analysis of river coal at Harrisburg is as follows:

	Per cent
Over 3/16 - - - - -	6.5
Through 3/16, over 3/32 - - - - -	25.85
Through 3/32, over 1/16. - - - - -	42.65
Through 1/16 - - - - -	25.00

As the sources of river coal are gradually eliminated the supply will be diminished. Creeks will gradually clean their channels and the industry will no longer be profitable. River coal will probably be dredged from the Susquehanna for 25 years or more. River coal is used for making briquettes and for the generation of power on Coxe stokers. It is quite popular in Harrisburg as a domestic fuel when it is burned on a wire screen or perforated plate with forced draft.

Sampling of Silt and Culm Banks. The sampling of the silt and culm banks and of the water discharge from breakers presents many interesting and valuable facts. It was upon this sampling that the detailed conclusions which have already been outlined were based. The sampling and analysis was done with painstaking care and by the most modern methods. The following table is representative of the detailed information which is contained in over 200 tables at the end of Bulletin M 12.

Analysis of sample of silt bank at
SHORT MOUNTAIN COLLIERY.

Size		Screen analysis		Chemical analysis				B.t.u. per pound
Thru	Over	Grams	Per cent of total	Ash	Sulphur	Vola- tile matter	Fixed carbon	
--	3/16"	64	2.4	39.4	.60	8.1	52.5	8800
3/16"	3/32"	367	13.8	28.0	.50	8.2	63.8	10780
3/32"	3/64"	655	24.3	21.0	.60	10.1	68.9	11910
3/64"	50 mesh	910	34.1	17.3	.60	10.7	72.0	12530
50 mesh	100 mesh	332	12.5	19.6	.50	9.1	71.3	12130
100 mesh	200 mesh	156	5.8	16.6	.70	9.4	74.0	12580
200 mesh	--	183	6.9	18.2	.60	8.9	72.9	12310
Total		2667	100.0	--	--	--	--	--
Average		--	--	20.5	.58	9.7	69.7	11885

A copy of the manuscript of this bulletin can be consulted at the office of the State Geologist, Harrisburg, until the bulletin appears in print.

